Available online at www.sciencedirect.com
ScienceDirect
Chemosphere 67 (2007) 1904–1910
CHEMOSPHERE
www.elsevier.com/locate/chemosphere

Abiotic degradation of triphenylborane pyridine (TPBP) antifouling agent in water

Xiaojian Zhou [a,1], Hideo Okamura [b,*], Shinichi Nagata [a]

[a] *Environmental Biochemistry Division, Research Center for Inland Seas, Kobe University, Fukaeminami 5-1-1, Higashinada, Kobe 658-0022, Japan*
[b] *Laboratory of Marine Environmental Management, Faculty of Maritime Sciences, Kobe University, Fukaeminami 5-1-1, Higashinada, Kobe 658-0022, Japan*

Received 9 May 2006; received in revised form 23 August 2006; accepted 5 December 2006
Available online 25 January 2007

Abstract

The abiotic degradation of the new antifouling agent, triphenylborane pyridine (TPBP), was investigated in buffer solutions having different pH values (pH 5, 7, and 9), and in artificial and natural seawater to estimate environmental fate of TPBP. The TPBP in these waters was decomposed by a seven-day hydrolysis process at 50 °C both in the dark and a photolysis process under UV-A irradiation using a high-pressure mercury lamp for periods up to 24 h. TPBP hydrolysis was significantly enhanced by acidic pH solutions. The photolysis rate of TPBP was higher in acidic pH solutions than in neutral or basic pH solutions, and was highest in natural seawater, which could have contained naturally dissolved organic matter.

Two degradation products, phenol and an unknown substance (Peak #1), were observed during the hydrolysis and photolysis studies of TPBP. The concentration of these substances after a one-day photolysis treatment was higher than after a seven-day hydrolysis treatment. The degradation rate of TPBP in the five test water samples was related to the simultaneous photolysis formation of phenol and Peak #1. However, the degradation rate of TPBP was not related to the formation of the hydrolysis products. Therefore, it is suggested that photodegradation of TPBP follows a different pathway to the hydrolysis degradation of TPBP. Our results indicate the chemical and photochemical reaction of TPBP in water occurs in natural aquatic environments.

Keywords: Biocide; Buffer solution; Environmental fate; Hydrolysis; Photodegradation; Seawater; UV-A

1. Introduction

Antifouling chemicals are used as biocides to deter the growth of organisms on the surface of submerged structures, such as ship's hulls and fishing nets. Organotin (OT) compounds, which have been used as major antifouling agents for several decades, have been regulated internationally since 1990 due to their severe impact on aquatic environments (Tanabe et al., 1998; Yamada and Kakuno, 2003). Many tin-free co-biocides have been developed and utilized in commercial antifouling paints as substitute compounds for OT complexes since the use of OT compounds was regulated (Voulvoulis et al., 1999). Much research has been devoted to Irgarol 1051 and diuron as representative biocides among the substitute OT compounds. One of the reasons for this is that these compounds are not difficult to be analyzed in environmental matrices, and another reason is their relatively high persistence in aquatic environments. Therefore, their environmental fate and impact on marine environments has been reported in the several literature references (Okamura et al., 2000; Thomas et al., 2002). However, there is little information available on other biocides because of the lack of suitable established analytical methods.

Triphenylborane pyridine (TPBP) is used as a biocide in ship hull antifouling paints in Japan (Okamura and Mieno,

* Corresponding author. Tel./fax: +81 78 431 6272.
E-mail address: okamurah@maritime.kobe-u.ac.jp (H. Okamura).
[1] Present address: Coastal Marine Laboratory, Department of Biology, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong.

0045-6535/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.chemosphere.2006.12.007